

CLAIMS

WE CLAIM:

1. An energy storage flywheel system, comprising:
 - a shaft;
 - a flywheel assembly mounted on the shaft;
 - one or more primary bearing assemblies each configured to selectively rotationally support the shaft;
 - one or more secondary bearing assemblies each configured to selectively rotationally support the shaft;
 - one or more secondary bearing position sensors each configured to supply position signals representative of a position of one or more of the secondary bearing assemblies;
 - a secondary bearing control circuit adapted to receive (i) one or more signals representative of primary bearing assembly operability and (ii) the secondary bearing assembly position signals and operable, in response thereto, to selectively supply actuator control signals; and
 - one or more secondary bearing actuator assemblies each coupled to one or more of the secondary bearing assemblies, each actuator assembly further coupled to receive the actuator control signals from the control circuit and operable, in response thereto, to move the secondary bearing assemblies to one of (i) an engage position, in which each secondary bearing assembly rotationally supports the shaft, and (ii) a disengage position, in which each secondary bearing assembly does not rotationally supports the shaft.

2. The system of Claim 1, wherein each secondary bearing actuator comprises:

a motor coupled to receive the actuator control signals and operable, in response thereto, to supply a drive force; and

an actuator coupled to receive the drive force and operable, in response thereto, to selectively move one or more of the secondary bearing assemblies between the engage and disengage positions.

3. The system of Claim 1, wherein the control circuit is further operable to selectively supply one or more brake control signals, and wherein each the system further comprises:

a brake assembly coupled to the secondary bearing actuator, the brake assembly further coupled to receive the brake control signals and operable, in response thereto, to selectively inhibit movement of one or more of the secondary bearing actuator assemblies.

4. The system of Claim 3, wherein the brake assembly comprises:

a first plate coupled to the secondary bearing actuator assembly, the first plate having at least a first surface and a second surface, the first surface having a plurality of teeth formed thereon;

a second plate having at least a first surface and a second surface, the second plate second surface located substantially opposed to the first plate first surface and having a plurality of teeth formed thereon; and

a brake actuator coupled to the second plate, the brake actuator coupled to receive the brake control signals and operable, in response thereto, to selectively move the second plate second surface into and out of engagement with the first plate first surface.

5. The system of Claim 1, wherein each primary bearing assembly comprises a magnetic bearing assembly, each magnetic bearing assembly adapted to be selectively activated and deactivated, and configured, when activated, to rotationally mount the flywheel assembly in non-contact manner, and wherein the system further comprises:

a magnetic bearing control circuit configured to supply magnetic bearing activation control signals to each magnetic bearing assembly and adapted to receive one or more magnetic bearing monitor signals, the magnetic bearing control circuit further configured, in response to the magnetic bearing monitor signals, to supply the signals representative of primary bearing assembly operability to the secondary bearing control circuit.

6. The system of Claim 1, wherein each of the secondary bearing assemblies comprises a mechanical bearing assembly.

7. The system of Claim 1, wherein the secondary bearing control circuit is further adapted to receive a signal representative of an electrical system supply voltage and is further operable, in response thereto, to selectively supply the actuator control signals.

8. The system of Claim 1, wherein each secondary bearing position sensor comprises a proximity sensor.

9. The system of Claim 1, wherein the secondary bearing position sensors comprise:

an engage position sensor configured to supply an engage signal when the secondary bearing assemblies are at least in the engaged position; and

a disengage position sensor configured to supply a disengage signal when the secondary bearing assemblies are at least in the disengaged position.

10. The system of Claim 9, further comprising:

a sensor mount structure disposed proximate at least one secondary bearing actuator assembly, the sensor mount structure having a main body that includes at least a first end and a second end, the sensor mount structure first end having the engage position sensor mounted therein and the sensor mount structure second end having the disengage position sensor mounted therein;

a position semaphore having at least a first end and a second end, the position semaphore first end coupled to the at least one secondary bearing actuator assembly and moveable therewith and the position semaphore second end disposed between the sensor mount structure first and second ends,

wherein the engage and disengage position sensors are each proximity sensors operable to supply position signals based on proximity thereto of the position semaphore.

11. The system of Claim 1, further comprising:

one or more bearing mount structures each coupled to one of the secondary bearing assembly actuator assemblies, each bearing mount structure having one or more of the secondary bearing assemblies mounted thereon,

wherein the secondary bearing actuator assemblies selectively move the bearing mount structures to thereby move the secondary bearing assemblies.

12. An auxiliary bearing control system for a shaft that is selectively rotationally supported by one or more primary bearing assemblies, comprising:

one or more secondary bearing assemblies each configured to selectively rotationally support the shaft;

one or more secondary bearing position sensors each configured to supply position signals representative of a position of one or more of the secondary bearing assemblies;

a secondary bearing control circuit adapted to receive (i) one or more signals representative of primary bearing assembly operability and (ii) the secondary bearing assembly position signals and operable, in response thereto, to selectively supply actuator control signals; and

one or more secondary bearing actuator assemblies each coupled to one or more of the secondary bearing assemblies, each actuator assembly further coupled to receive the actuator control signals from the control circuit and operable, in response thereto, to move the secondary bearing assemblies to one of (i) an engage position, in which each secondary bearing assembly rotationally supports the shaft, and (ii) a disengage position, in which each secondary bearing assembly does not rotationally supports the shaft.

13. The system of Claim 12, wherein each secondary bearing actuator comprises:

a motor coupled to receive the actuator control signals and operable, in response thereto, to supply a drive force; and

an actuator coupled to receive the drive force and operable, in response thereto, to selectively move one or more of the secondary bearing assemblies between the engage and disengage positions.

14. The system of Claim 12, wherein the control circuit is further operable to selectively supply one or more brake control signals, and wherein the system further comprises:

a brake assembly coupled to one or more of the secondary bearing actuator assemblies, the brake assembly further coupled to receive the brake control signals and operable, in response thereto, to selectively inhibit movement of one or more of the secondary bearing actuator assemblies.

15. The system of Claim 14, wherein the brake assembly comprises:
a first plate coupled to the secondary bearing actuator assembly, the first plate having at least a first surface and a second surface, the first surface having a plurality of teeth formed thereon;

a second plate having at least a first surface and a second surface, the second plate second surface located substantially opposed to the first plate first surface and having a plurality of teeth formed thereon; and

a brake actuator coupled to the second plate, the brake actuator coupled to receive the brake control signals and operable, in response thereto, to selectively move the second plate second surface into and out of engagement with the first plate first surface.

16. The system of Claim 12, wherein the secondary bearing control circuit is further adapted to receive a signal representative of an electrical system supply voltage and is further operable, in response thereto, to selectively supply the actuator control signals.

17. The system of Claim 12, wherein each secondary bearing position sensor comprises a proximity sensor.

18. The system of Claim 12, wherein the secondary bearing position sensors comprise:

an engage position sensor configured to supply an engage signal when the secondary bearing assemblies are at least in the engaged position; and

a disengage position sensor configured to supply a disengage signal when the secondary bearing assemblies are at least in the disengaged position.

19. The system of Claim 18, further comprising:

a sensor mount structure disposed proximate at least one secondary bearing actuator assembly, the sensor mount structure having a main body that includes at least a first end and a second end, the sensor mount structure first end having the engage position sensor mounted therein and the sensor mount structure second end having the disengage position sensor mounted therein;

a position semaphore having at least a first end and a second end, the position semaphore first end coupled to the at least one secondary bearing actuator assembly and moveable therewith and the position semaphore second end disposed between the sensor mount structure first and second ends,

wherein the engage and disengage position sensors are each proximity sensors operable to supply position signals based on proximity thereto of the position semaphore.

20. The system of Claim 12, further comprising:

one or more bearing mount structures each coupled to one of the secondary bearing assembly actuator assemblies, each bearing mount structure having one or more of the secondary bearing assemblies mounted thereon,

wherein the secondary bearing actuator assemblies selectively move the bearing mount structures to thereby move the secondary bearing assemblies.

21. In an energy storage flywheel system having at least a flywheel shaft and one or more primary bearing assemblies configured to selectively rotationally support the flywheel shaft, a method of selectively rotationally supporting the flywheel shaft via one or more secondary bearing assemblies, comprising:

determining whether the primary bearing assemblies are operable to rotationally support the flywheel shaft;

upon determining that the primary bearing assemblies are not operable to rotationally support the flywheel shaft, moving at least one of the secondary bearing assemblies from a disengaged position to an engaged position, to thereby rotationally support the flywheel shaft via the secondary bearing assemblies; and

supplying a position signal representative of secondary bearing assembly position at least when one of the secondary bearing assemblies engages the shaft.

22. The method of Claim 21, further comprising:

selectively inhibiting movement of the at least one secondary bearing assembly in at least the engaged and disengaged positions.

23. The method of Claim 21, wherein the energy storage flywheel system is adapted to electrically couple to an electrical distribution system, and wherein the method further comprises:

determining a voltage magnitude of the electrical distribution system; and

if the voltage magnitude is below a predetermined value, moving at least one of the secondary bearing assemblies from a disengaged position to an engaged position, to thereby rotationally support the flywheel shaft via the secondary bearing assemblies.